Matching LED and Incandescent Aviation Signal Brightness

John D. Bullough, Ph.D.
Lighting Research Center, Rensselaer Polytechnic Institute

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LRC and Aviation Lighting Research

Aviation Lighting Research at the LRC

Human Factors

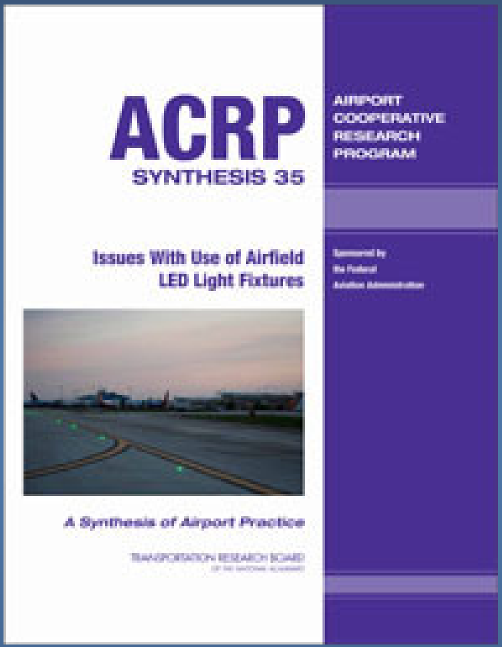
Color Vision Status and LED Identification
Signal Light Brightness
Perception of Linear Lighting
Effective Intensity of Flashing Lights
Stroboscopic Effect Perception
Requirements for LED Runway Guard Lights
Specifications for Remote Airfield Lighting

Solid State Lighting Technology

Heat Transfer in Taxiway Edge Lights
Life Testing for Airfield Lighting Fixtures
Solar-Powered LED Fixtures
Volatile Organic Compound Effects in LEDs
LED Driving Circuitry and Flicker
Photometric Testing for LED Fixtures
Electrical Infrastructure Research Team Support
Phosphor-Converted Amber LEDs
Junction Temperature Estimation for AC LEDs
LED Electrical and Thermal Parameters Under Stress

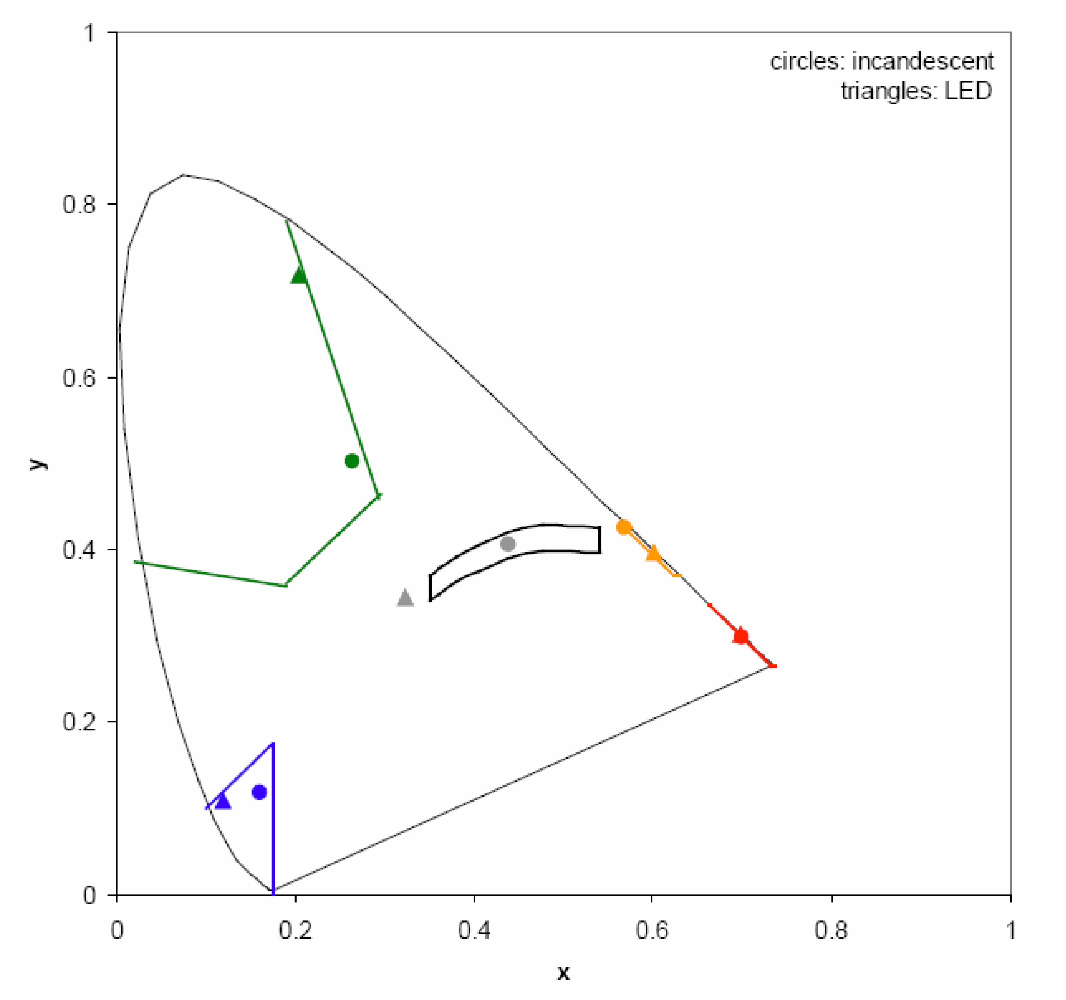
Background

- LED lighting technology is increasing in use for airfield lighting
  - Potential for maintenance and energy benefits
- LEDs differ from incandescent sources in several important ways:
  - Increased color saturation and higher correlated color temperature (CCT) for white
- What are the brightness/luminous intensity characteristics of LED aviation signal light colors, relative to incandescent?



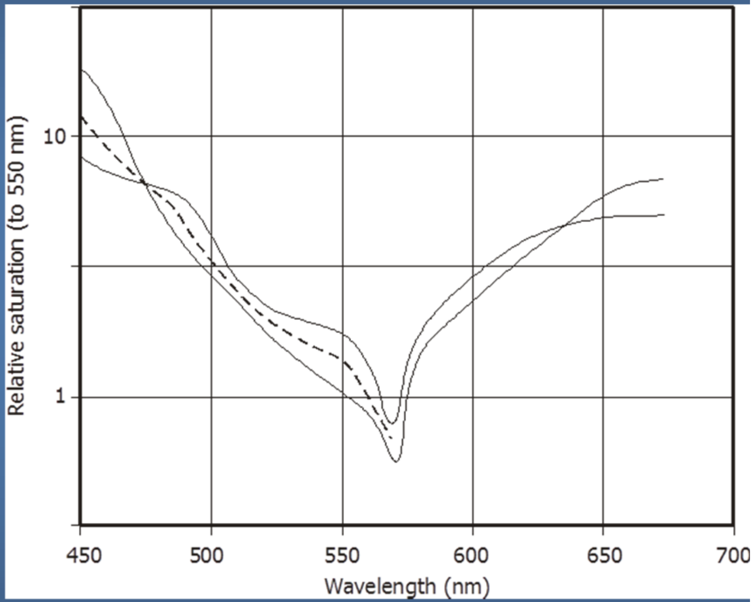
(Bullough 2012)

Incandescent and LED Signal Chromaticities



What Influences Brightness?

- Factors related to brightness include (Kaiser and Boynton, 1996):
  - Excitation purity (saturation)
  - Hue
- LED signal lights can differ from incandescent signals of the same nominal color in both saturation and hue
  - For some colors (particularly white, blue and green), more than one LED type might be able to be used



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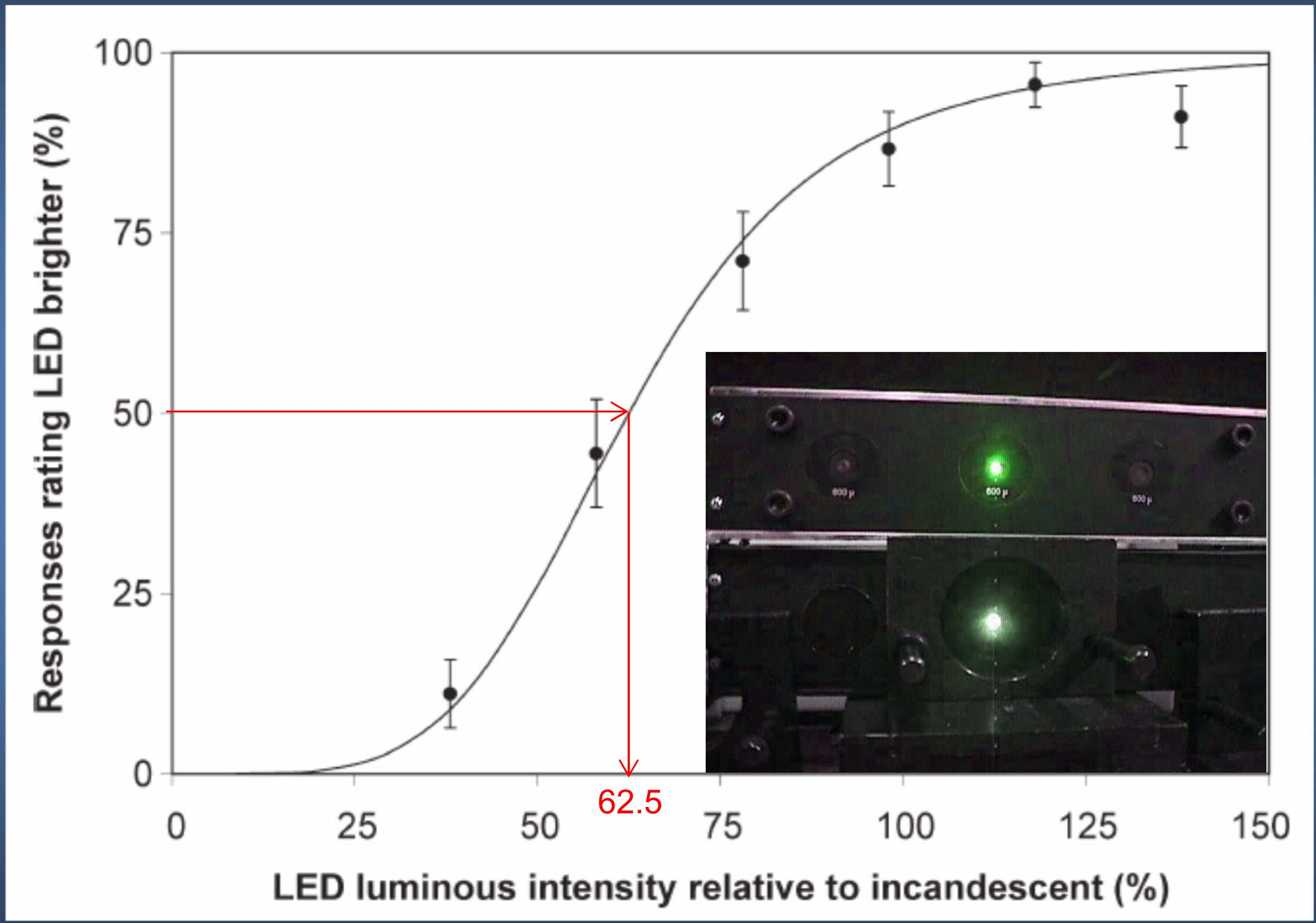
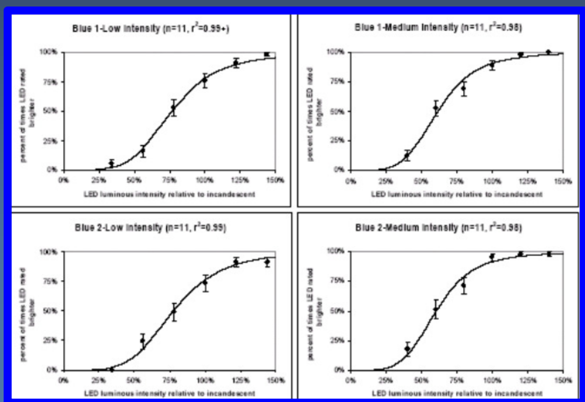
Psychophysical Brightness Measurement



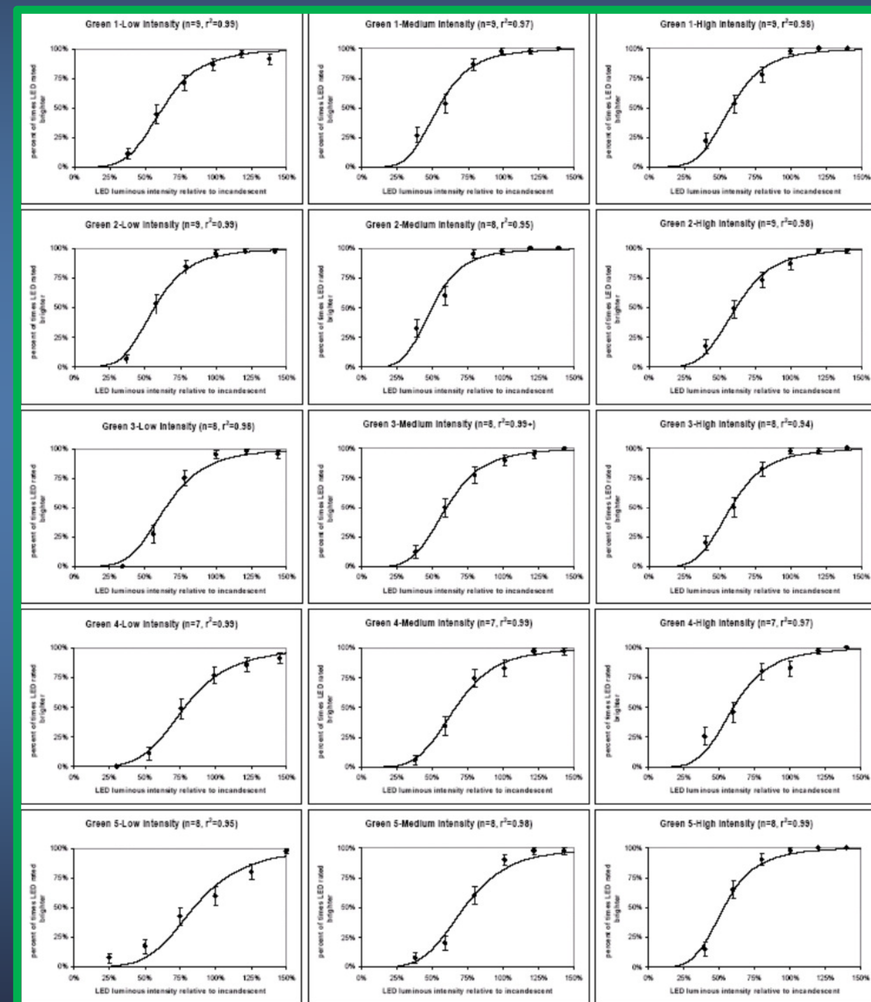
(Bullough et al. 2007)

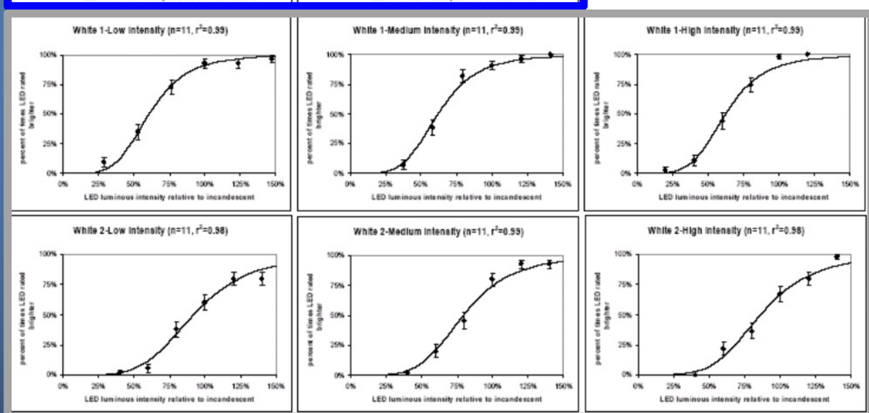
Experimental Data

Blue



Green





White

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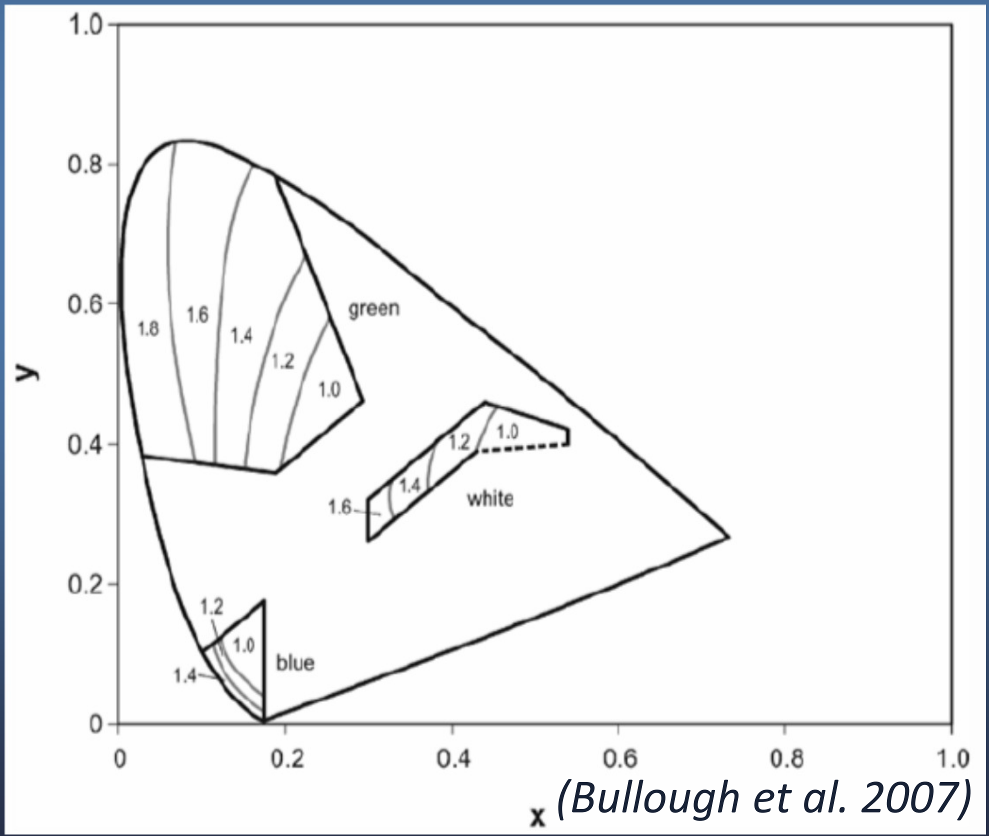
Brightness-to-Luminous Intensity (B/L) Values

- B/L value for an LED source is defined as the reciprocal of the relative luminous intensity needed to achieve equal brightness as an incandescent source of equal nominal color



(Bullough et al. 2007)

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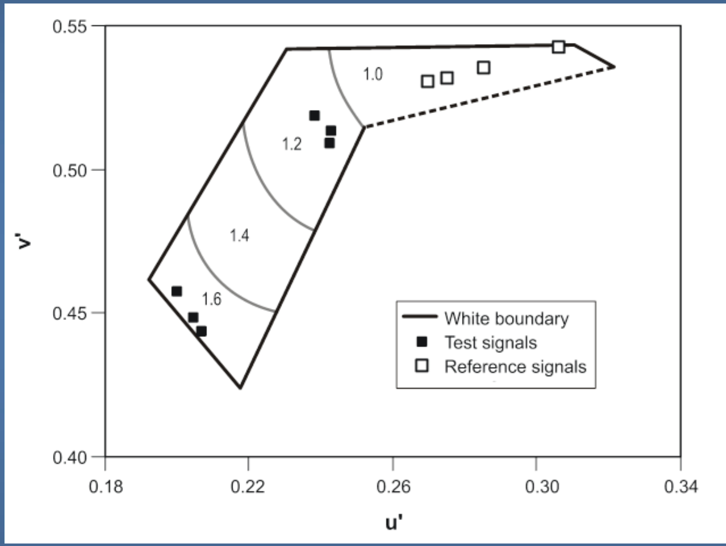
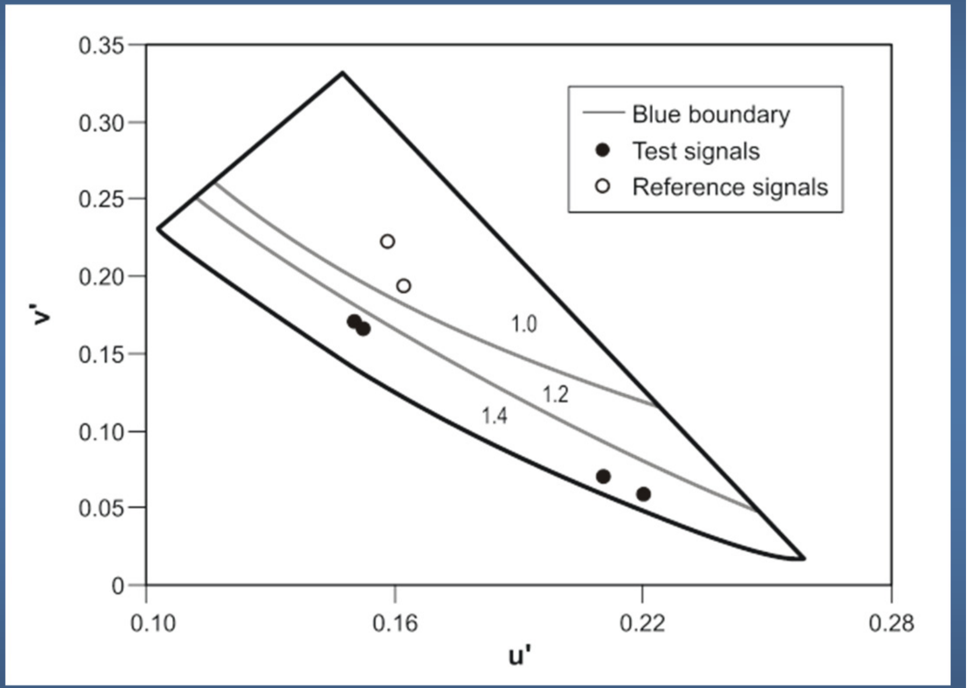
B/L for White LEDs

- Incandescent white signals have CCTs of 2700 K (lower when dimmed); white LEDs range from 2700 K to 8000 K
- 3300 K LED: B/L = 1.2
  - LED intensity can be **83%** of incandescent
- 7100 K LED: B/L = 1.6
  - Outside present white boundary
- 6100 K LED: B/L = 1.5 (near left edge of chromaticity region for white specified by Engineering Bulletin 67D)
  - LED intensity can be **67%** of incandescent



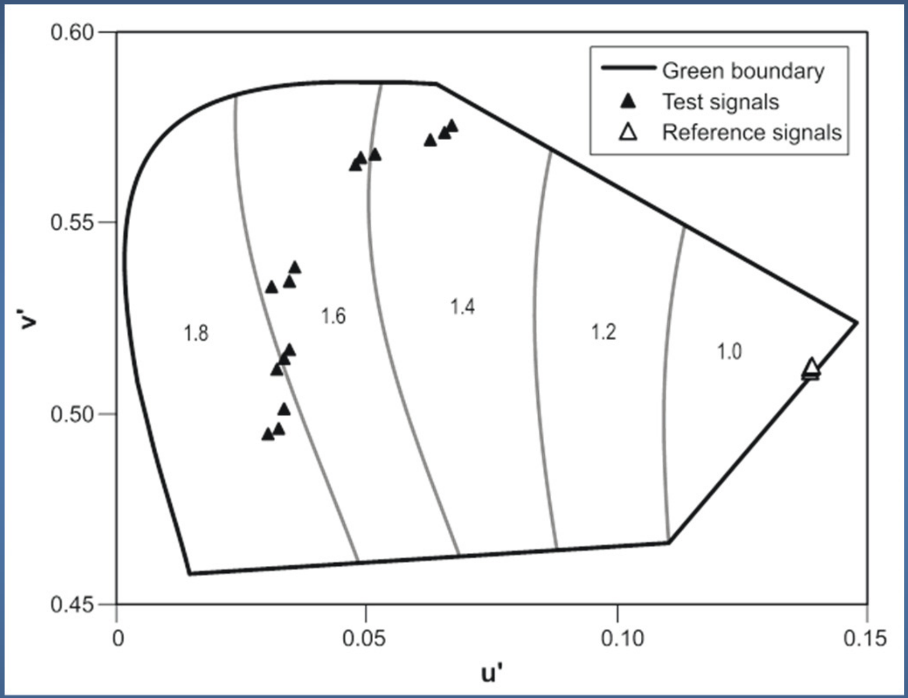
B/L for Blue LEDs

- Blue LEDs can have peak wavelengths of 470 nm (“blue”) or 450 nm (“royal blue”)
- 470 nm (Blue) LED: B/L = 1.4
  - Intensity can be **72%** of incandescent
- 450 nm (Royal Blue): B/L = 1.4
  - Intensity can be **72%** of incandescent



B/L for Green LEDs

- Green LEDs can have peak wavelengths from 525 nm ("green") to 505 nm ("cyan")
- 525 nm (Green) LED: B/L = 1.4
  - Intensity can be **72%** of incandescent
- 505 nm (Cyan): B/L = 1.65
  - Intensity can be **61%** of incandescent



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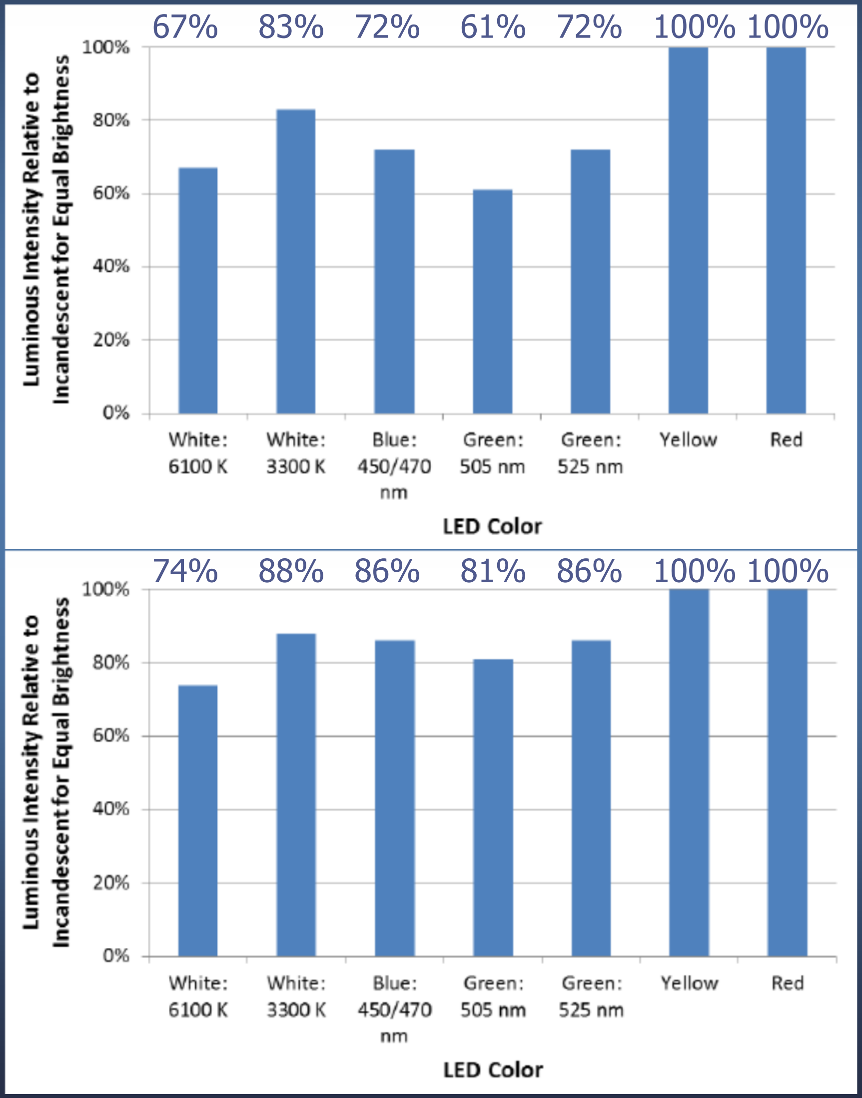
B/L for Yellow and Red LEDs

- LED and filtered incandescent spectra for yellow and red signal light colors do not result in dramatically different chromaticities (Bullough et al. 2000)
  - Yellow LED: B/L = 1.0
    - Intensity must be **100%** of incandescent
  - Red LED: B/L = 1.0
    - Intensity must be **100%** of incandescent

Influence of Fog

- Scattered light in fog is superimposed over signal light images, reducing the differences between their chromaticities (and relative brightness)



(Bullough et al. 2007)

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Discussion

- For the same luminous intensity, LED signals will produce equivalent or higher perceived brightness than incandescent signals of the same nominal color
  - Specific differences depend upon the hue and saturation characteristics of the specific LED types used
  - For white, blue and green LEDs, intensity could be reduced while maintaining brightness equal to incandescent
- Brightness differences are reduced in fog conditions
  - Operational control to equalize LED and incandescent intensity in fog may be desirable to prevent LED signals from appearing less bright than incandescent signals

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Thank you!

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